

## DIFFUSER IN AN AIR MASS FLOW CONTROLLER

### *Claim for Priority*

[0001] This application claims the benefits of U.S. Provisional Application Nos. 60/255,717 and 60/255,713, both filed on December 15, 2000, which are hereby incorporated by reference in their entirety.

### *Field of the Invention*

[0002] This invention relates to an air mass flow controller in general, and more particularly to a diffuser in an air mass flow controller valve for fuel cells containing several flow passages, each controlled independently by an associated electro-mechanical actuating device.

### *Background of the Invention*

[0003] It is believed that a fuel cell consists of two electrodes sandwiched around an electrolyte. It is believed that oxygen, from air, passes over one electrode and hydrogen, from one or more storage device, passes over the other electrode, that, in a chemical reaction, generates electricity, water and heat.

[0004] The electricity generated by a fuel cell is believed to be regulated at least in part by the amount of air or oxygen delivered to the fuel cell. Where the fuel cell includes a plurality of fuel cell units, it is believed that there is a need to accurately regulate the amount of air or oxygen delivered to each fuel cell unit. It is further believed that the flow of air or oxygen passing through an air mass flow sensor must be laminar and equally distributed.

### *Summary of the Invention*

[0005] The present invention provides a diffuser for an air mass flow controller for fuel cells. The diffuser can be used to deliver laminar and equally distributed flow of air or any other gases to fuel cells. The diffuser includes a housing, an inlet, a first bank of outlets, and a second bank of outlets. The housing has walls, which define a volume. The inlet is disposed along a first axis and is coupled to a first one of the walls. The first bank of outlets is disposed along a second axis and is coupled to a second one of the walls. The first bank of outlets is in fluid communication with the inlet. The second

bank of outlets is disposed along a third axis and is coupled to the second wall. The second bank of outlets is in fluid communication with the inlet and the first bank of outlets.

[0006] The present invention also provides a method of providing laminar and equally distributed airflow through a diffuser having walls defining a volume, an inlet coupled to a first one of the walls and being disposed along a first axis, first and second banks of outlets coupled to a second one of the walls, the first bank of outlets disposed along a second axis and being in fluid communication with the inlet, the second bank of outlets disposed along a third axis and being in fluid communication with the inlet and the first bank of outlets. The method includes flowing air through the inlet; flowing air through an interior of the housing; and directing air through the first and second banks of passages.

### ***Brief Descriptions of the Drawings***

[0007] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate an embodiment of the invention, and, together with the general description given above and the detailed description given below, serve to explain the features of the invention.

[0008] Figure 1 is an orthogonal view of an air mass flow controller valve according to a preferred embodiment of the invention.

[0009] Figure 2 is a cross-sectional side view of the air mass flow controller valve.

### ***Detailed Description of the Preferred Embodiment***

[0010] In the drawings, like numerals are used to indicate like elements throughout. A preferred embodiment, shown in Figures 1 and 2, is a diffuser for an air mass flow controller valve 10 for fuel cells. The air mass flow controller valve 10 can deliver air to a reformer of a fuel cell (not shown) on board a vehicle or anywhere else that is necessary, such as, for example, in a fuel cell generating plant. In particular, as shown in the figures, the diffuser includes, preferably, a housing 30, an inlet 20, a first bank of outlets 40, and a second bank of outlets 42. The housing 30 has walls, which define a volume. The volume of the housing 30 can be rectangular, spherical, ellipsoidal, or any other polygonal shape. Preferably, the volume of the housing 30 is rectangular. The

inlet 20, is disposed along a first axis A. The inlet 20 can be a cylindrical tube. In other words, the cross-section of the inlet 20 can be circular. The cross-section of the inlet 20 can be rectangular or any other polygonal cross-sectional shape. Preferably, the cross-section of the inlet 20 is circular. The inlet 20 has an inlet portion 22, which can be a flange, and a base portion 24, which is coupled to a first wall 32 of the housing 30. A wall thickness of the inlet 20 can be substantially similar to a wall thickness of the first wall 32.

**[0011]** The diffuser includes the first bank of outlets 40 disposed along a second axis B. The first bank of outlets 40 are coupled to a second wall 38 of the housing 30. The first wall 32 and the second wall 38 can be disposed opposite one another. The first bank of outlets 40 are in fluid communication with the inlet 20. Each one of the first bank of outlets 40 can be cylindrical tubes. In other words the cross-section of each one of the first bank of outlets 40 can be circular. The cross-section of each one of the first bank of outlets 40 can be rectangular or any other polygonal cross-sectional shape. Preferably, the cross-section of each one of the first bank of outlets 40 is circular. Inlet portions 34 of the first bank of outlets 40 protrude into an interior 31 of the housing 30.

**[0012]** The diffuser includes the second bank of outlets 42 disposed along a third axis C. The first bank of outlets 40 can be offset from the second bank of outlets 42. The second bank of outlets 42 are coupled to the second wall 38 of the housing 30. The second bank of outlets 42 are in fluid communication with the inlet 20 as well as with the first bank of outlets 40. Each one of the second bank of outlets 42 can be cylindrical tubes. In other words the cross-section of each one of the second bank of outlets 42 can be circular. The cross-section of each one of the second bank of outlets 42 can be rectangular or any other polygonal cross-sectional shape. Preferably, the cross-section of each one of the second bank of outlets 42 is circular. Inlet portions 36 of the second bank of outlets 42 protrude into the interior 31 of the housing 30. Wall thicknesses of the inlet portions 36 of the second bank of outlets 42 can be greater than a wall thickness of the second wall 38 of the housing 30. Although not shown, wall thicknesses of the inlet portions 34 can be greater than the wall thickness of the second wall 38 of the housing 30. End portions 46 of the inlet portions 36 of the second bank of outlets 42 can include smooth radii 48. Although not shown, end portions 44 of the inlet portions 34 of

the first bank of outlets 40 also include smooth radii. The end portions 46 of the inlet portions 36 of the second bank of outlets 42 and the end portions 44 of the inlet portions 34 of the first bank of outlets 40 can include sharp ends or angles. Preferably, the end portions 46 of the inlet portions 36 of the second bank of outlets 42 and the end portions 44 of the inlet portions 34 of the first bank of outlets 40 are smooth radii. Inner diameters of the inlet portions 36 that protrude into the housing 30 can be less than inner diameters of the second bank of outlets 42 that extend beyond the second wall 38 of the housing 30. Although not shown, inner diameters of the inlet portions 34 that protrude into the housing 30 can be less than inner diameters of the first bank of outlets 40 that extend beyond the second wall 38 of the housing 30.

[0013] Details of one of the plurality of second passages 52 shown will now be described. The configuration of the plurality of first passages (not shown) is substantially similar to that of the plurality of second passages 52, and thus, will not be described. The passage 52 is coupled to a distal end of one of the second bank of outlets 42. As used herein, the term "distal" refers to a position with respect to the housing 30. The passage 52 can be coupled to one of the second bank of outlets 42 by, for example, lock-fit, screws, rivets, or adhesives. Preferably, the passage 52 is coupled to one of the second banks of outlets 42 by a lock-fit, as shown. A pressure sensor 50 is disposed downstream of the second bank of passages 42. Preferably, the pressure sensor 50 is disposed on an inner wall of the passage 52. The pressure sensor 50 can be a hot-wire type or resistive type pressure sensor. Preferably, the pressure sensor 50 is a hot-wire type pressure sensor. A seat portion 62 can present a generally flat seating surface 64 on which a sealing member (not shown), preferably an O-ring, is disposed thereon. The seat portion 62 can include an opening extending through the seat portion 62 along a fourth axis D. A closure member 60 can be disposed, in one position proximate the sealing member (not shown) of the seat portion 62. The closure member 60 can be movable to a plurality of positions along the fourth axis D, including a first position and a second position. When the closure member 60 is in the first position, air can flow between one of the second banks of passages 42 and an exit passage 70, whereas in the second position, the closure member 60 prevents communication between one of the second banks of passages 42 and the exit passage 70. The closure member 60 can have a stem

65 that can be disposed along the fourth axis D and a seating member 67. The stem 65 and the seating member 67 of the closure member 60 can be formed as a two-piece assembly. Preferably, the stem 65 is integrally formed with the seating member 67. The seating surface 64 can be disposed in a confronting arrangement with the seating member 67 of the second closure member 60. Again, the seating surface 64 of the seat portion 62 can also include at least one sealing member (not shown), such as an O-ring, disposed between the seating surface 64 of the seat portion 62 and the seating member 67 of the second closure member 60.

[0014] In order to move the second closure member 60 to different positions along the fourth axis D, an actuating device 80 can be provided to actuate independently of the other closure members. The actuating device 80 can be pneumatic or electrical.

Preferably, the actuating device 80 is electromagnetic and includes an armature assembly 82 coupled to the closure member 60. The armature 82 can be disposed and displaceable along the fourth axis D when electromotive forces are introduced into electromagnetic coil 85. The electromotive force introduced to the coil 85 induces the generation of electromagnetic flux in the electromagnetic coil 85 that flows to the armature 82. The flow of magnetic flux to the armature 82 tends to move the armature 82 toward an armature stop 84 so as to complete a magnetic circuit from the coil 85 to the armature 82, the armature stop 84, and back to the coil 85. Upon deactivation of the device 80, a sliding bearing 86 can be provided to act as a stopper for the armature 82. Data from the pressure sensor 50 can be used to determine an air mass amount.

[0015] When the device 80 is actuated, the magnitude of displacement of the armature assembly 82 is generally equivalent to the amount of air permitted to flow between one of the second banks of passages 42 and the exit passage 70. The actuating device 80 is responsive to the pressure sensor 50 to regulate the amount of air flow between the inlet 20 and the exit passage 70 as a function of target air mass amount or a target air mass flow rate. Preferably, the actuating device 80 can be controlled by electrically connecting the coil 85 to a controller (not shown) that outputs a pulsedwidth-modulated signal. Here, the pulsedwidth-modulated signal represents the target air mass amount or the target air mass flow rate as determined by the controller (not shown). The pulsedwidth-modulated signal can be feedback controlled by a “processed signal” from

one of the pressure sensors 50 and to the controller (not shown). As used herein, the term "processed signal" indicates that the signal from the pressure sensor 50 can be processed by an analog to digital converter, and then subsequently treated so that this processed signal can be used to determine the feedback error signal to control the actuating device 80.

**[0016]** The operation of the diffuser 30, in the air mass flow controller valve 10, will now be described. Specifically, in the actuating device 80, the armature 82 acts in response to signals provided by a controller or by the pressure sensor 50 to regulate the flow of air by displacing the closure member 60 between the first position and the second position. In the first position, the closure member 60 is unseated. Thus, air that flows into the inlet 20 flows through the diffuser housing 30 where air flow becomes laminar and is equally distributed to the first bank of passages 40 and the second bank of passages 42. The air flows past the closure member 60 and through the plurality of exit passages 70. In the second position, the closure member 60 is seated against the seat portion 62 and the sealing member (not shown). Thus, air that flows into the inlet 20 and the diffuser housing 30 is prevented from flowing through the plurality of exit passages 70 by the seating of the closure member 60. Air flow through each of the individual passages can be regulated independently of one another by the individual actuating devices 80 and their associated closure members 60 and pressure sensors 50.

**[0017]** While the present invention has been disclosed with reference to certain embodiments, numerous modifications, alterations and changes to the described embodiments are possible without departing from the sphere and scope of the present invention, as defined in the appended claims. Accordingly, it is intended that the present invention not be limited to the described embodiments, but that it has the full scope defined by the language of the following claims, and equivalents thereof.